EFFECTS OF FETAL AND EARLY LIFE DEVELOPMENT AND ELECTROMAGNETIC EXPOSURE: A POSSIBLE CONTRIBUTOR TO LEARNING PROBLEMS

by
Cheryl L. Bogen

A Graduate Project
Submitted to the
Faculty of the Graduate College
in partial fulfillment
of the
Degree of Masters of Education

University of Dayton
Dayton, Ohio
December 7, 1991

DEDICATION

Dedicated to the children of the future in hopes that the findings of this study may allow them to experience the pure joy of unclouded learning.

ACKNOWLEDGEMENTS

Thank you, thank you, thank you to the following people for helping me "arrive".

To my husband, Mark, for the untold sacrifices he made and the incredible job he did as stand in Mom over the past five years while I followed my own personal rainbow back and forth to Dayton.

To my father -- who still remains my role model even though he has been gone for almost 16 years.

To my mother and sister for always being there to listen and advise when ever I needed them.

To Dr. Roger Carlsen (who knew I'd be in Special Education two years before I did) for his help, guidance and support on this new-beginnings project.

Approved by:

Official Advisor

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Chapter I will support the purpose for this study. Following the introduction, the remainder of the chapter will include: (a) the assumptions and limitations of this study, (b) the key definitions, (c) hypothesis to be tested, and (d) a statement identifying the significance of this research.

This study will attempt to determine if there is a correlation between a child who has lived in a house that has an unsafe level of electromagnetic radiation and his subsequent identification as being a gifted, learning disabled, or normal student.

As an educator in the field of special education, this author works daily with learning disabled children. One of the great mysteries of this type of handicap is the causes. In their book, Kirk and Chalfant, stated that along with suspected brain injuries that cause obvious cerebral dysfunction, scientists are still searching for specific causes. "The most common etiological factor hypothesized as a cause of learning disability is brain damage or minimal brain dysfunction (MBD) acquired before, during, or after birth. Dysfunction of the brain can have

prenatal, perinatal, or postnatal origins" (Kirk and Chalfant, 1984, p. 45). Other studies have shown some evidence for the inheritance of learning disabilities. Some learning disabled children seem to have no known neurologic or genetic problems, so a connection with biochemical imbalance has been hypothesized. There have also been studies to try to find links between a lack of early environmental stimulation; nutritional deficits; and even allergies (1984).

It is not known what causes learning disabilities. Research is on-going and will continue until conclusive cases are determined. Whereas there are many kinds of learning disabilities, it is logical to assume a variety of causes.

Ours is a world of modern conveniences. Our homes and businesses are full of high-tech inventions that help us do our work faster, easier, cleaner and safer. We've become a society that, for decades, has begun to expect more and more technological advances that we can use to solve our problems and make our lives easier. While we expected these advances to be made available to us, most individuals assumed that the power and byproducts of that power which was needed to run our technological world were safe.

As Borrell pointed out, the government, regulatory bodies, and industry did not have a good track record for protecting consumers (1990). One can recall how lead, mercury, asbestos, DDT, or tobacco were allowed to be used.

In recent years a new area of concern has been brought to the attention of consumers -- the possible risks to health from the extremely low levels of magnetic fields generated by electric currents. These fields were created by AC

current as it alternated back and forth 60 times a second in the circuits that carried electricity. The more current flowing through a wire, the stronger the magnetic field (Kirkpatrick, 1990). The wavelengths this author was concerned with were the very long wavelengths called ELF (extremely low frequency) that fall at the low end of the electromagnetic spectrum. These fields were also generated near power lines.

With the recent influx of articles of concern (Cunningham, 1991; Borrell, 1990; Foster & Guy, 1986; Kirkpatrick, 1990) correlating exposure to electromagnetic fields produced by power lines and certain appliances with an increased risk of cancer, this author was forced to wonder about other possible effects. Was there any correlation between exposure to low-level alternating-current electromagnetic fields and learning disabled, regular, and gifted students? Researchers have proven the existence of electrical currents in parts of the nervous system. An apparatus called a superconducting quantum interferometric device (SQUID, for short) was invented in 1964 by Nobel Prize winning physicist Brian D. Josephson. This SQUID has confirmed the existence of a direct-current perineural system, which, especially in the brain, produces steady DC magnetic fields one billionth the strength of earth's field of about one-half gauss. Researchers have found that a magnetoencephalogram (MEG) gives an accurate reflection of the mental activity of the brain and can locate the current source more accurately than EEG (electroencephalogram) measurements. So far, research seems to have established that every electrical evoked potential

is accompanied by a magnetic evoked potential. Thus, there is true electrical activity and not just discharged nerve impulses. Becker (1985) states that:

> Since every reaction and thought seems to produce an evoked potential, the DC system seems directly involved in every phase of mental activity. At the very least, the electric sheath acts as a bias control, a sort of background stabilizer that keeps the nerve impulses flowing in the proper direction and regulates their speed and frequency. But the analog structure probably plays a more active role in the life of the mind. Variations in the current from one place to another in the perineural system apparently form part of every decision, every interpretation, every command, every decision, every feeling, and every word of interior monologue, conscious or unconscious, that we conduct in our heads. (p. 241)

Assuming then, the importance of this electrical current in basic brain function, the problems that could be caused by interfering electromagnetic fields is portentous.

Further studies by Becker et. al. in 1967 confirmed that abnormal magnetic fields did produce abnormalities (slowed reaction times and generalized stress) in various human and animal responses.

If there is proof of produced abnormalities, it seems reasonable to believe that there could be a connection to learning disabilities. The purpose of this study was to determine if there was a connection between learning disabled children and their exposure to low-level, alternating-current electromagnetic fields.

ASSUMPTIONS AND LIMITATIONS

The range in the birth dates of the children's houses that were tested was from 8-11-73 to 8-4-82. An assumption that must be made is that the power to these homes, and consequently, the electrical field, has been the same during the entire 18-year period from the birth of the oldest subject until the readings were taken by the author in September, 1991.

There are numerous gaussmeters available on the market. The Power Pet that this author chose is simple in design. To determine whether an electromagnetic field is present, the user must simply hold the Power Pet still in one of three directions (horizontal, vertical, or sideways) while depressing a button. The results are indicated by either a green light (meaning less than 1.5 milliGauss at 60 Hz), a flashing red light (1.5 to approximately 2.5 milliGauss at 60 Hz), or solid red (over 2.5 milliGauss at 60 Hz). More exact readings can be determined by using different meters that show findings in numeric results. The ranges the Power Pet gave allowed this author to see critical windows of extremely low frequency (ELF) radiation.

KEY DEFINITIONS

Circadian rhythms -- natural biological cycles that occur in approximate 24-hour periods

EEG -- Electroencephalogram, the tracings of brain waves Electrical evoked potential -- evoked potential as measured by an EEG

Electromagnetic spectrum -- the range of electromagnetic radiation from ELF (very long wave lengths) to Gamma and X-rays (very short wave lengths)

ELF fields -- extremely low frequency fields of electromagnetic radiation that fall at the low end of the electromagnetic spectrum

Evoked potential -- a particular electrical response in the brain to a single stimulus

gauss -- A unit of measure for magnetic-field strength named after Karl Friedrich Gauss, a nineteenth- century German pioneer in the study of magnetism.

gifted student -- A student is selected to be part of an enrichment program designed to fill his educational needs if he qualifies in four different areas. 1) Students must score at least a 95th percentile composite score on an achievement test and/or at least a 127 standard score on an intelligence test. 2) Interviews involving individual intelligence and creativity tests administered by the teacher of the gifted program. 3) Point ranking is then done in the

previously mentioned areas in an attempt to narrow the field. 4) Final selection is made by a panel composed of building principals, teacher representatives, school psychologist, and the gifted teacher.

learning disabled student -- In this study, a student is identified after a multi-step process that starts with 1) a referral from a classroom teacher; 2) testing by a speech pathologist for language-related problems; 3) educational testing and assessment by the psychologist; 4) a team meeting consisting of the psychologist; principal; learning disability teacher; speech pathologist, if necessary; and the regular classroom teacher. During this meeting, it is determined if the student legally qualifies for services by having a 20 point discrepancy between ability and achievement in any one area, or if the child is so low-functioning that an override is recommended. Finally (5) a special meeting is held with the student's parents in order to draw up an individualized educational plan.

MBD -- Minimal brain dysfunction or brain damage.

MEG -- magnetoencephalogram, a recording of changes in the brain -- often a more accurate record of mental activity than the EEG

Normal student -- A student performing at an apparently average level. One with neither an exceptionally high nor low performance.

Power Pet ® Gaussmeter -- ELF milliGauss meter. Inside the meter is a loop of wire. When magnetic radiation is present, it passes through this loop of wire inducing a current in the wire which is indicated by the green, flashing or solid red light.

VDT -- Video display terminal

windows of effect -- ranges of frequency or intensity where an effect occurs -- but at both lower and higher frequencies or intensities, it seems to disappear.

HYPOTHESIS

There is no significant difference between exposure to low-level alternating-current electromagnetic fields and learning disabled, regular, or gifted students.

SIGNIFICANCE OF THE STUDY

There are no conclusive causes for learning disabilities. Much research in other areas has determined that the prenatal period of fetal development up to about the age of 11 years is critical in the development of a healthy child. During early cell mitosis in an organism, there is tremendous potential risk with each division. Considering the billions of cell divisions necessary to create a finished organism, it is a miracle that most people are "normal". It is fact that consumption of alcohol or use of cocaine by a pregnant woman can cause birth defects ranging in degree from slight (physical mutations) to gross (death).

Surgeon, Cynthia Illingworth of Sheffield Children's Hospital in England, has documented several hundred cases of complete fingertip regeneration in children involved in accidental injury to fingers. Other studies have also confirmed that fingers lost at the outer joint will invariably regrow perfectly. All of these regenerations took place in children who were eleven years old or younger (Becker, 1985).

With such a significant potential for damage, especially during the first critical eleven year - nine month period this author was concerned with the possibility of fetal damage due to exposure to unsafe levels of electromagnetic fields. Due to the electrical nature of brain functioning, it seemed possible that the electromagnetic fields could interfere with the normal brain development in the fetus and the young child, thus perhaps causing or contributing to learning disabilities.

CHAPTER II

REVIEW OF LITERATURE

The question asked and the suggested hypothesis presented in this paper are new research. Consequently, this author didn't have an abundant list of resources available to provide specific information linking electromagnetic fields and learning disabilities.

Initial sources were from magazines such as Macworld, Scientific America, Fortune, and even Red Book, and Ladies' Home Journal. Questions were being asked regarding the safety of proximity to power lines; use of computer video display terminals; electric blankets, clocks, and other commonly used electrical appliances; and microwaves. Direct connections to magnetic field impact on the learning disabled were not in the literature.

There were also numerous televised programs on USA Tonight, ABC's Good Morning America, Nightline, CBS News, and others with these same questions being asked about the safety and degree to which electromagnetic fields might be harmful. Links to increased rates of miscarriage, cancer and childhood leukemia were being discussed. Affects to heart rate and the central nervous system were mentioned, but often only in passing. Experts say that there is

evidence that the risk is real and that there are changes identified in the biological systems. Experts are of the belief that the problem must be resolved through high-level research.

For years, surgeons have been successfully using pulsed ELF fields to speed the healing of broken bones even though it is not clearly understood how it works (Kirkpatrick, 1990). Since World War II, electromagnetic fields at lower frequencies have been employed for therapeutic heating of tissue. Initially the only known hazard was thought to be burns or other damage from excessive tissue heating (Foster and Guy, 1986). There were concerns with the safety of VDT's. Researchers at the Northern California Kaiser Permanente Medical Care Program wrote that they found that women who worked with VDTs for more than 20 hours a week experienced an increased risk of both early and late miscarriage that was 80 percent higher than the risk for women who performed similar work without using VDTs (Borrell, 1990). Another study of almost 500 children in the Denver area found that those whose mothers used electric blankets during pregnancy were 2.5 times more likely to contract brain tumors than children whose mothers did not use electric blankets (Kirkpatrick, 1990).

An area that has, in recent years, been brought to the attention of the public is the concern of the possible health risk related to the magnetic field given off by the power lines that link most American homes to originating power stations. Epidemiologist, Nancy Wertheimer was the first to identify the possible connection between ELF fields and cancer. Her study, published in 1979, " ...

suggested that the homes of children who developed cancer were found unduly often near electric lines carrying high currents" (Brodeur, 1989, p. 22). The study went on to say "that current flow (and, by extension, the magnetic fields induced by current flow) was always greatest in electrical wires leading from a distribution substation or a pole-mounted transformer. It was particularly homes close to these transforming points that were over-represented among our cancer cases" (Brodeur, 1989, p. 22). Wertheimer found that children in these high-current houses were two to three times as likely as the others to die of lymphomas, nervous system tumors or leukemia.

It must be stressed that even though these figures were significant, the overall risk from ELF fields appeared much lower than from many already known carcinogens. As a point of comparison, Wertheimer's figures of two to three times the risk compared to a figure of 20 times greater for chain smokers to get lung cancer (Kirkpatrick, 1990).

Another problem for the scientists studying serious illness related to electromagnetic fields was the correlational nature of data. Thus, no single cause or contribution to such problems could be identified. "While scientists have shown that fields can have biological effects, they can find no clear relation of dose to response. A number of experiments with ELF fields have found so-called *windows of effect*, ranges of frequency or intensity where an effect occurs -- but at both lower and higher frequencies or intensities, it seemed to disappear" (Kirkpatrick, 1990, p. 84).

Compounding problems were apparently exasperated because of the finds of relationships between exposure and the direction and intensity of the earth's static magnetic field. Other factors were brought to light which included data that indicated that intermittent, not continuous exposure may have a greater biological effect. Carl Blackman, EPA research biophysicist, has listed duration of exposure, time of day, age, shape of the waves in the field, the angle of the field, and the subsidiary frequencies that accompany a main frequency as variables that affect the risk involved. "It gets so complex, you just want to throw up your hands" (Kirkpatrick, 1990, p. 84).

One of my major sources for information was the book *The Body Electric*, written by Robert O. Becker, an orthopedic surgeon who became interested in the regenerative aspects of bone healing. He found research written by a Soviet biophysicist who had measured negative electrical currents flowing from wound sites of tomato plants where branches had been cut off. Subsequent readings indicated that these currents reversed polarity to a positive charge as the wounds were healing over and new branches were beginning to form near the cuts. When Becker conducted experiments comparing the current at the site of injury in a frog and a salamander (who has remarkable regenerative powers) he found that both sites initially had a positive charge. The salamander site, however, became highly negative while the new limb started to regenerate. The frog's site stayed positive as the injury site healed over with no indication of any regeneration. The importance of this wasn't the polarity itself, but the fact that there was a change

in polarity that "seemed to be related to reparative growth" (Becker, 1985, p. 61). Further study led Becker to discover that this negative charge caused a subatomic response that initiated the regenerative process. Becker postulated that there might be a data-transmission and control system which regulated growth and healing in the entire system. "He further reasoned that such a system might consist of a constant electric current associated with the nervous system, a current that could transmit information about injury to the brain and carry appropriate repair signals back to the site of the injury. After obtaining evidence for this theory by measuring DC electric current flowing throughout the body of the salamander, he hypothesized that the direction of flow and the magnitude of this current might also control brain activity and consciousness" (Brodeur, 1989, p. 26-27). This, too he was able to prove by inducing deep anesthesia in a salamander by placing it in a strong magnetic field. Other research by Becker and psychologist Howard Friedman, showed that there was a relationship between the admission of patients to the psychiatric services of hospitals and the occurrence of solar magnetic storms (Brodeur, 1989). Additional research showed a relationship to increased stress (indicated by decreased water intake, enlarged adrenal and pituitary glands, and altered protein and hormone ratios in the blood) in animals exposed to pulsed magnetic fields. The magnetic fields used in these studies were within the ELF range of one to thirty hertz, which is the frequency of the earth's natural magnetic field. Becker became alarmed when he considered what damage man-made ELF fields -- those produced by our 60-hertz

electrical distribution system-- might be doing to human health. Becker states that:

> We now know that very small electrical currents are generated by living organisms and that they are important regulators of growth and the operations of the central nervous system. Similarly, it has been discovered that the brain itself, as well as other organs, actually produce magnetic fields detectable outside of the body. Within the past decade, we have found that living organisms have specific organs, developed very early in evolution, whose job it is to sense the changes that occur in the earth's magnetic field and alter the organisms behavior appropriately. Finally, only within the last year have we begun to understand the actual physical mechanisms involved in these interactions between very small magnetic fields and living things (p. 209-219).

Only since 1900 has our electromagnetic environment been changed drastically over the past three billion years of life. The introduction of fields and frequencies from advanced needs for energy and communication, never before existing, are abundant. Becker feels that "this change in our natural environment is actually the most drastic alteration made by mankind and is far greater than any chemical contamination yet recorded" (Brodeur, 1898, p. 210). Electromagnetic fields could already be having a widespread effect on human health by impairing the immune system and altering normal cell division. Recent statistics show that the incidence of birth defects has approximately doubled over the past twenty-five years; the incidence of cancer in general is increasing approximately one percent per year; serious mental disorders are present in twenty percent of the general population, and at forty percent in people under forty-five; teenage suicide has more than doubled from 1961 to 1981. "It is recognized that our society contains other factors that may contribute to this

fields (who's brain tissue would have been exposed during embryonic development) with those incubated in 50-hertz electrical fields who's brain tissue would not have been affected) to determine if the responses of the brain tissues might have been altered by the 60-hertz exposure. When comparing the two, entirely different responses were found. "The physiological significance of this difference remains unclear, but the findings clearly demonstrate that exposing a developing chick in ovo to power-line frequency electric fields can alter the responses of the brain tissue of the chicken after it has been hatched" (Brodeur, 1989, p. 143).

Other research was done in the 1960's and 1970's by Rutgers Wever, a physicist at the Max Planck Institute of Physiology, in Germany. Wever discovered that volunteers who were put into underground bunkers; completely isolated from all outside noise and activity, and shielded from all external electric and magnetic fields; developed their own circadian rhythms completely different to the normal twenty-four hour pattern. However, when exposing the volunteers to direct-current and alternating-current electric fields of ten hertz, the circadian rhythms were affected in the same way as those who had been exposed to the natural electromagnetic fields of the earth (Brodeur, 1989).

In his book, Brodeur made one reference to learning disabilities produced in rats by ELF fields. In an attempt to garner more specific information on this, Mr. Brodeur was contacted by the telephone. He stated that the studies he had alluded to were done by Kurt Salzinger at the Brooklyn Polytechnic Institute in

Brooklyn, New York. He further stated that the learning disabilities were present in not just the first generation, but also in subsequent generations of rats (Brodeur, 1991). This would definitely be research that would be important to investigate further.

CHAPTER III

METHOD AND PROCEDURE

When choosing the subjects to be tested for this study, the author had several requirements that needed to be met. It was necessary to locate subjects who 1) lived at the same location while their mother was pregnant with them until the time they were 2) officially identified by the school system as being either learning disabled, gifted, or normal. These contacts were made through conversations and inquiries to regular teachers, teachers involved in special education, and friends who the author knew had children who had been identified as learning disabled.

Once the test subjects and their addresses were identified, the author made a site visit to each home and measured the perimeter of the house for electromagnetic fields using a Power Pet ® gaussmeter made by Safe Technologies Corporation. The Power Pet ® is designed so that areas with chronic 60 Hertz (Hz) magnetic radiation can be located and "safe" areas

determined. The Power Pet ® is designed so that by simply pressing a button, a light indicates areas of different levels of magnetic radiation by changing from green (less than 1.5 milliGauss at 60 Hz), to flashing red (1.5 to approximately 2.5 milligauss at 60 Hz), to solid red (above approximately 2.5 milligauss at 60 Hz).

Since magnetic fields are directional, it was necessary to take readings at each site from at least three different directions in order to get an accurate measurement. This was done simply by holding the Power Pet ® flat, vertical, and sideways. Each of these three different readings were charted and identified for each house as being either G (green), F (flashing), or R (red).

The Results chapter contains the chart showing each house number; the three different directional readings of the gaussmeter (horizontal, vertical, and sideways) indicated as either green, flashing, or red; the educational status of all the children, and the order of birth for students in that house that met the initial requirements for inclusion in the study.

These data were analyzed and the findings and results are presented in Chapter IV.

CHAPTER IV

RESULTS

This study was conducted to determine if there was a relationship between a student label (i.e. normal, gifted, or learning disabled) and the ELF level in the house where they were conceived, born and reared. A student was chosen to be part of this study if he lived in the same house from the time his mother was pregnant with him until the time he was identified as being an exceptional student.

A total of twenty-six homes were identified that had children who had lived in them through the mother's pregnancy until school age. In these homes, there were thirty-three (33) normal, fourteen (14) gifted, and eight (8) learning disabled students.

The data was collected and recorded as indicated in Chapter III, Method and Procedure. The collected data was then analyzed as follows:

Table 1. DATA TABLE

l the children were conceived, born and reared in these houses.

HOUSE	METER READING			CHILD ORDER OF BIRTH & LABEL			
	HORIZ	VERT	SIDE	1	2	3	4
1	G	F	F	N	N	L	
2	G	F	F	N	N		
3	G	G	G	N			
4	G	G	G	N	N		
5	G	G	G	N	N		
6	G	G	G	N	G		
7	F	F	F	N	N	L	
8	G	G	G	G	G		
9	G	G	G	N			
10	G	G	G	G			
11	G	G	G	G	G		
12	G	G	F	G	G	N	N
13	G	G	G	N			
14	G	G	G	N	N		
15	F	G	G	L			
16	G	F	F	N	N	L	
17	G	F	F	N	N	L	
18	G	G	G	G	N		
19	G	G	G	N	N	G	G
20	G	F	G	G			
21	F	R	R	G	G		
22	G	G	G	N	N		
23	G	F	G	N	N	L	
24	G	F	G	L			
25	G	G	G	N	N		
26	G	F	G	N	N	L	

R METER READING, G=GREEN, F=FLASHING, AND R=RED UNDER CHILD LABEL. N=NORMAL, G=GIFTED.

Actual meter scores (i.e. ratio or interval scores) were not obtained. Only cluster scores of less than 1.5 milliGauss, 1.5 to approximately 2.5 milliGauss, and more than approximately 2.5 milliGauss were gathered because of the use of the Power Pet. As a result, only descriptive and non parametric analyses were possible.

Table 2. Meter Reading at Students' Homes			
Category of Students	Number and % < 1.5 Milligauss	Number and % 1.5 to 2.5 Milligauss	Number and % > 2.5 Milligauss
Gifted	9 64.3%	3 21.4%	2 14.3%
Normal	17 51.5%	16 48.5%	0 0%
LD	0 0%	8 100%	0 0%

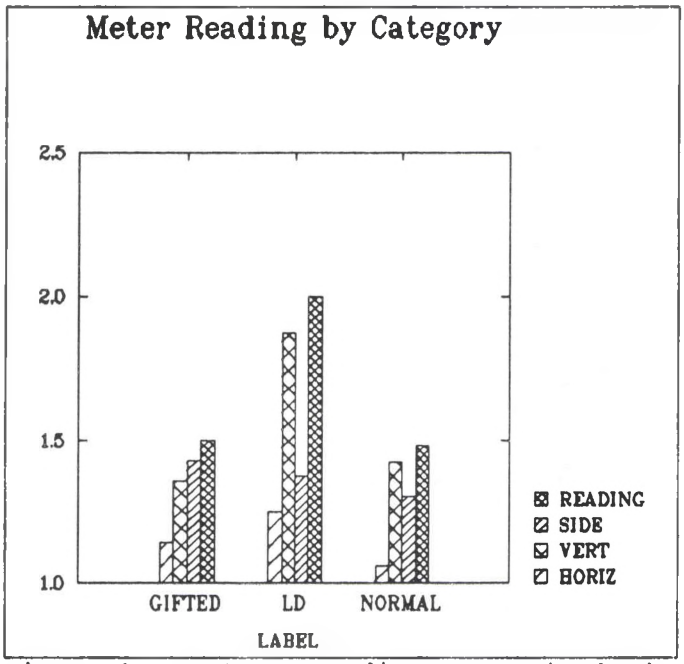

Figure 1. Meter readings examined by Category

Figure 1. From a visual perspective, a clear difference among the gifted, learning disabled and normal children's environments was distinct. While the houses of the learning disabled were <u>all</u> in the 1.5 to 2.5 milliGauss range, the LD students also shared another difference from the other students - the positioning of the meter. When the meter was held in a vertical position, the apparent critical level of magnetic

field was detected. When the scores are transformed to interval data, the meter readings become significant between normal and learning disabled students ($t=2.371$, $p=0.023$ with $df=39$).

CHAPTER V

SUMMARY AND DISCUSSION

Chapter V presents a discussion of this study and its findings. The final part of this chapter will present this author's recommendations. This study was carried out in an attempt to determine if there is a relationship between a child who has lived in a house that has a higher than normal level of electromagnetic radiation and his subsequent identification as being a gifted, learning disabled, or normal student.

Numerous studies done in the past 20 years concerning the effects of electrical and the subsequent magnetic fields on various aspects of life led this author to believe that there was a good possibility that excessive exposure to electromagnetic fields could have some correlation to learning disabilities.

Subjects were chosen for this study based on several requirements. It was necessary to locate subjects who 1) lived at the same location while their mother was pregnant with them until the time they were 2) officially identified by the school system as being either learning disabled, gifted, or normal.

Once the subjects and their homes were identified, the electromagnetic field was measured from various points around the perimeter of the house. The

readings were done with a gaussmeter called the Power Pet, manufactured by Safe Technologies. Because of the directional character of magnetic fields, each site reading was taken from three different directions, flat, vertical, and sideways.

Readings were charted and the data analyzed.

Main Findings

Twenty-six different homes were identified as having children who had lived in them from the time their mother was pregnant with them until the time they had been identified by the school as being a normal, gifted, or learning disabled student. In these homes lived thirty-two normal, fourteen gifted, and eight learning disabled children. The most significant results produced were in regards to the homes of the learning disabled students. In all eight of their homes, the electromagnetic field was found to be in the Flashing range, or 1.5 to 2.5 milligauss at 60 hertz -- a level that is considered unsafe.

Another test was run comparing the direction the gaussmeter was held during and three different readings at each house. The chart, see Figure 1, shows that, especially for the learning disabled student, the readings taken while the meter was being held in the vertical direction showed the most occurrence of electromagnetic fields.

Implications

Considering the strong evidence of the important role electricity plays in the basic functioning of the brain and central nervous system, and the undeniable evidence proving that exposure to excessive electromagnetic fields can cause or promote different types of detrimental effects to the body, it seems reasonable, along with the evidence presented by this author's findings, to believe that there may be a correlation between fetal and early childhood exposure to electromagnetic fields and learning disabilities.

Recommendations

Based on the findings of this study, it is very evident that more research must be done on this topic. More homes and enlarged sample size should be used to measure electromagnetic fields.

It would be interesting to see if there is a correlation to learning disabled children who did not necessarily live in a house during fetal development, but spent a great deal of their early life in a house that had excessive ELF levels. Is the critical period during fetal development, early life, or both?

Another interesting study would involve tracking children who were born as high risk babies who spent time in neonatal intensive care nurseries. Do the various isolets, and life-sustaining equipment used to sustain life produce unsafe

electromagnetic levels, and how many of these children experience learning disabilities once in school?

The electromagnetic fields in schools, especially in the computer labs and around the classroom computer need to be measured. If further study upholds the findings presented in this project it will be necessary to protect the students while using the computers in our schools.

The well-documented behavioral signs of critical ELF exposure closely resemble the behaviors associated with behavior problems, stress and attention deficit problems (ADHD).It would be worthwhile to explore the possible connections.

An interesting note from the data collected showed that six of the eight learning disabled children tested, were third child in the birth order. Is there a biological reason for this? Is the mother's body more susceptible to ELF in subsequent pregnancies?

This study has exposed just the tip of the iceberg -- there is tremendous opportunity to help answer some of the questions of what causes or contributes to learning disabilities. How incredible if the incidence of learning disabilities could be reduced by simply changing the electric wiring in our homes, and being aware of the potential hazards some electrical appliances present to developing fetuses.

NOTES

Brodeur, Paul. Telephone conversation held on Friday, November 29, 1991.

REFERENCES

Cunningham, Ann Marie. Danger in the Air. *Ladies' Home Journal.* July, 1991.

Becker, Robert O. & Selden, Gary. *The Body Electric,* New York: William Morrow, 1985.

Brodeur, Paul. *Currents of Death,* New York: Simon and Schuster, 1989.

Borrell, Jerry. Is Your Computer Killing You?. *Macworld.* July, 1990.

Editor. Your Health. *Redbook.* June, 1991.

Foster, Kenneth R. & Guy, Arthur W. The Microwave Problem. *Scientific American.* September, 1986.

Kirk, Samuel A. & Chalfant, James C.. *Academic and Developmental Learning Disabilities.* Denver: Love Publishing Company, 1984.

Kirk, Samuel A. & Gallaher, James J.. *Educating Exceptional Children.* Boston.: Houghton Mifflin Company. 1986.

Kirkpatrick, David. Can Power Lines Give You Cancer? *Fortune.* December 31, 1990.

Macauley, David. *The Way Things Work.* Boston.: Houghton Mifflin Company. 1988.

Wilkinson, L. *SYSTAT: The System for Statistics.* Evanston, IL: Systat, Inc., 1990.